

National Aeronautics and Space Administration



# NASA's Earth Science Division Bureaucratic Overview for the MODIS Science Team

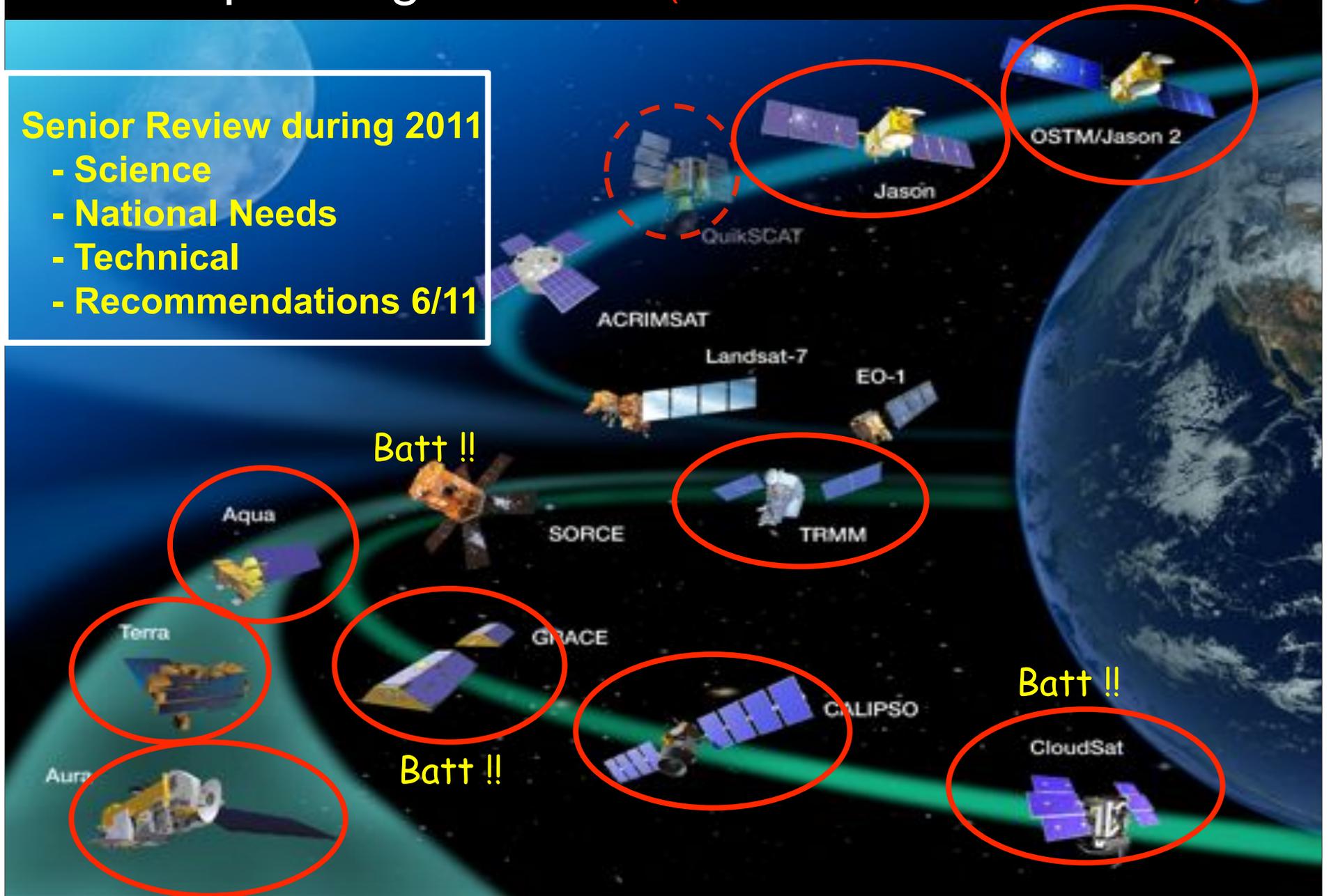
18 May 2011

# NASA Operating Missions (International Collaboration)

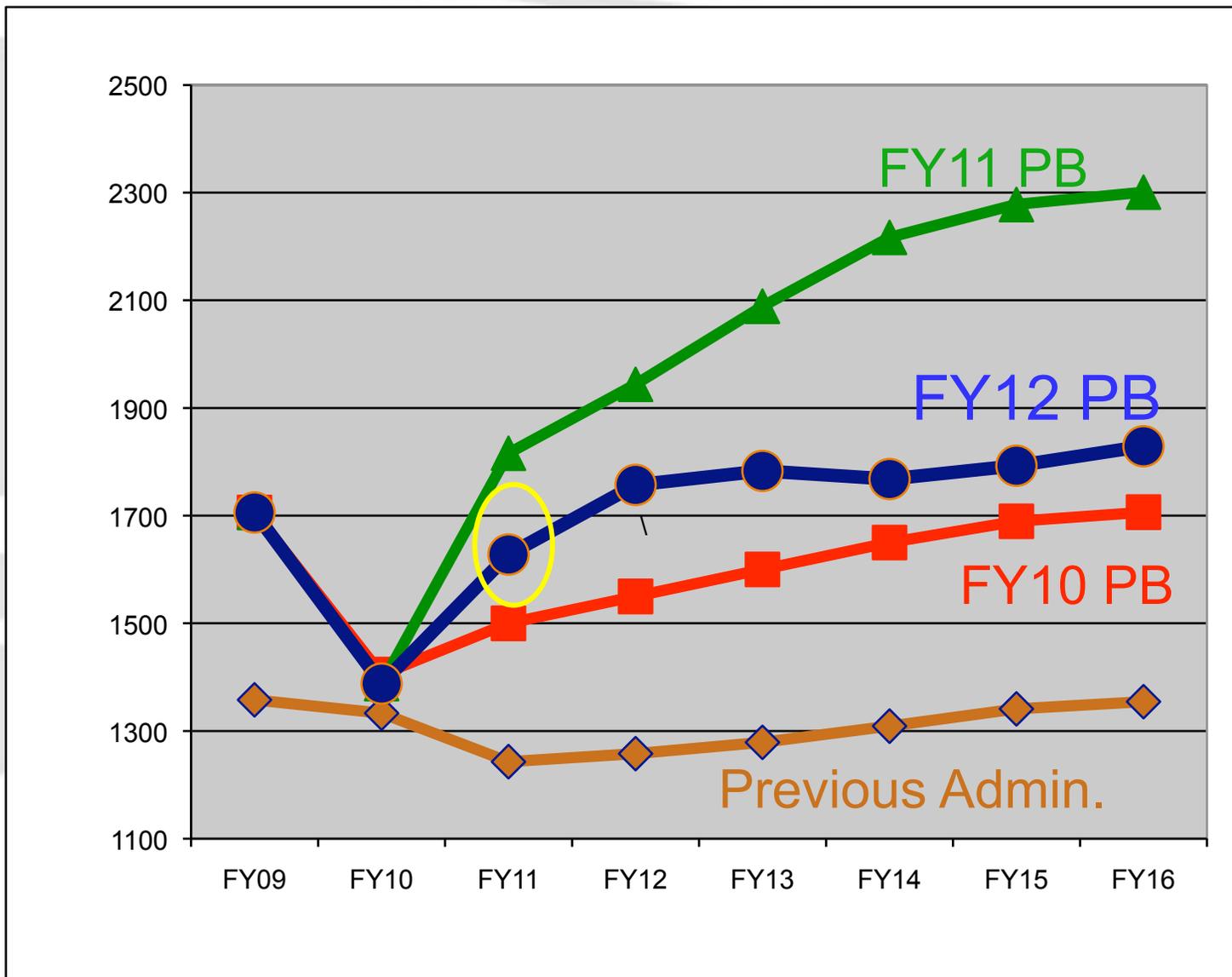


Senior Review during 2011

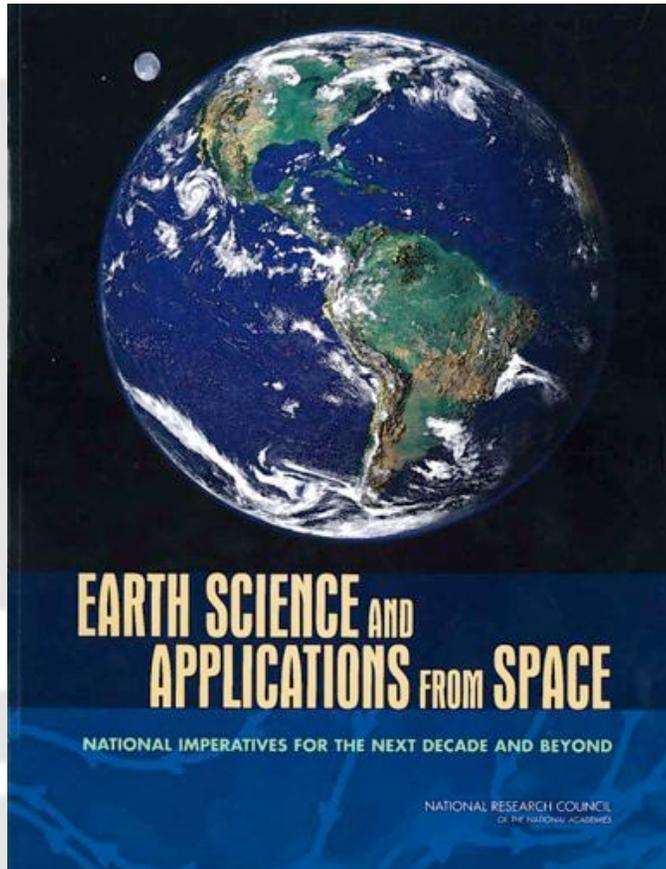
- Science
- National Needs
- Technical
- Recommendations 6/11



# BUDGET OUTLOOK (incl. FY11 Appropriation)



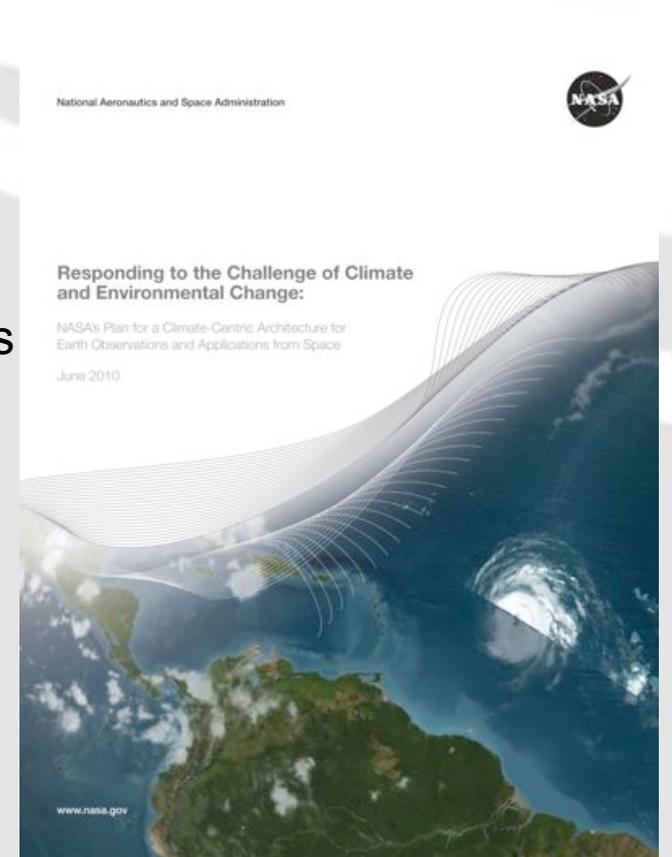
# Guiding Recommendation Documents



Administration priorities  
and constraints



Decadal survey,  
OCO-2,  
climate continuity  
missions,  
balanced program  
***Integrated Program***



## 2007 Decadal Survey

- Research and Applications communities priorities
- No realistic budget constraint (calls for \$2B funding [FY06 constant \$\$ beginning in FY10])

[http://science.nasa.gov/media/medialibrary/2010/07/01/Climate\\_Architecture\\_Final.pdf](http://science.nasa.gov/media/medialibrary/2010/07/01/Climate_Architecture_Final.pdf)

- Dec Surv + Administration priorities
- Executable for FY11 Pres. Bud.
- OSTP, USGCRP, OMB approval

# Missions in Formulation and Implementation – 4/2011



GLORY  
3/4/2011  
Aerosols, TSI



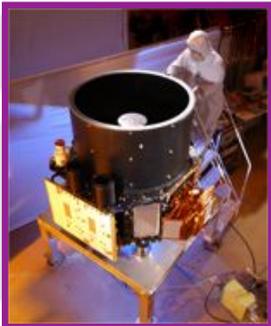
AQUARIUS  
6/9/2011  
w/CONAE; SSS



NPP  
10/25/2011  
w/NOAA  
EOS cont., Op Met.



LDCM  
12/2012  
w/USGS; TIRS



ICESat-II  
Likely 2016  
Ice Dynamics



SMAP  
Early CY2015  
w/CSA  
Soil Moist., Frz/Thaw



GPM  
7/2013 ???  
w/ JAXA; Precip



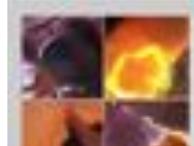
OCO-2  
2013 ???  
Global CO<sub>2</sub>

# Glory Aftermath/Status



- **Glory mission was lost - LV failure (fairing non-sep) on 4 March**
  - Total Irradiance Monitor (TIM) and Aerosol Polarimetry Sensor (APS) + Cloud Cameras
  - Refurbished Vegetation Canopy Lidar satellite bus
  - Taurus-XL failure has similar manifestations to OCO loss (24 Feb 2009)
- **Way forward: Glory**
  - Carbon-copy Glory recovery mission will *not* be developed – VCL bus obsolete
- **Way forward: TIM**
  - SORCE, ACRIMSAT missions continuing through at least 2016
  - TSIS instrument development passed KDP-C in 1/2011 (reimbursable, NOAA-funding to NASA SMD/JASD)
  - Instrument delivery planned late CY2012; no s/c or LV yet identified
- **Way forward: APS**
  - Science viability study – 90-days (due late June)
    - Utility of flight of APS-capability sensor in 3-5 years
    - Possible NRC (or ESS) review
  - Implementation study for APS replacement mission – 120 days (late July)
    - Cost, schedule, instrument approach, satellite approach, LV
  - No recovery mission without top-line ESD budget augmentation
    - Same programmatic approach as for OCO-2

# Future Orbital Flight Missions – 2011 – 2022



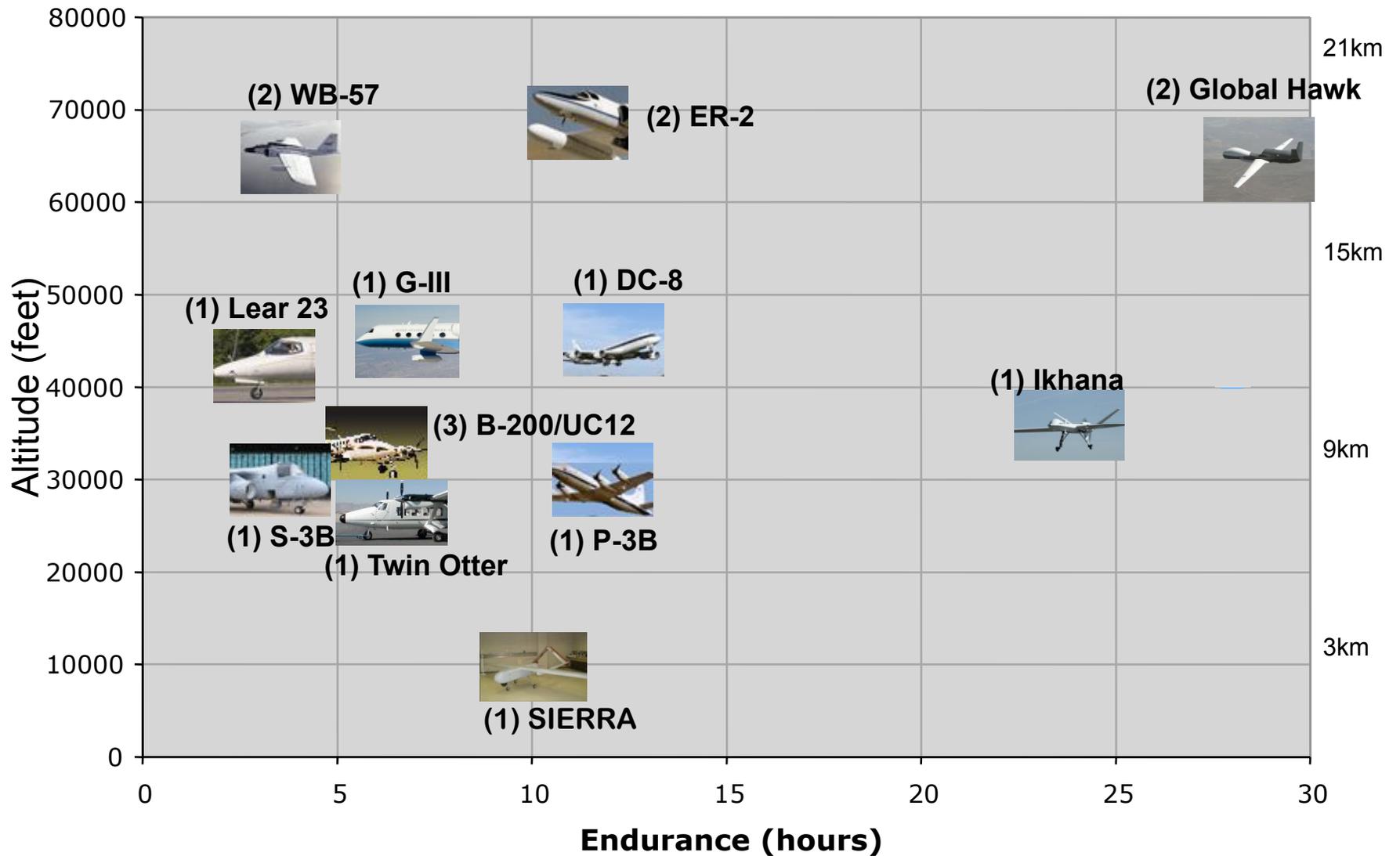
# VENTURE-CLASS UPDATE/STATUS



- **Venture-Class is a Tier-I Decadal Survey recommendation**
  - Science-driven, PI-led, competitively selected, cost- and schedule-constrained, regularly solicited, orbital and suborbital
  - Venture-class investigations complement the systematic missions identified in the Decadal Survey, and provide flexibility to accommodate scientific advances and new implementation approaches
- **Venture-Class is fully funded, with 3 “strands”**
  - EV-1: suborbital/airborne investigations (5 years duration)
    - Solicited in FY09 (selections in FY10) **and every 4 years**
    - 5 investigations selected; flights beginning in FY11
  - EV-2: small complete missions (5 years duration)
    - Solicited in FY11 (selections in FY12) **and every 4 years**
    - Small-sat or stand-alone payload for MoO; \$150M total development cost
    - Final AO release in May, 2011
  - EV-Instrument: Spaceborne instruments for flight on MoO (5 years dev.)
    - Solicited in FY11 (selections in FY12) **and annually thereafter**
    - Final AO release in 2<sup>nd</sup> half of FY11
    - ~\$90M development costs, accommodation costs budgeted separately <sup>8</sup>
    - Common Instrument Interface specs being developed



# NASA Airborne Science Aircraft

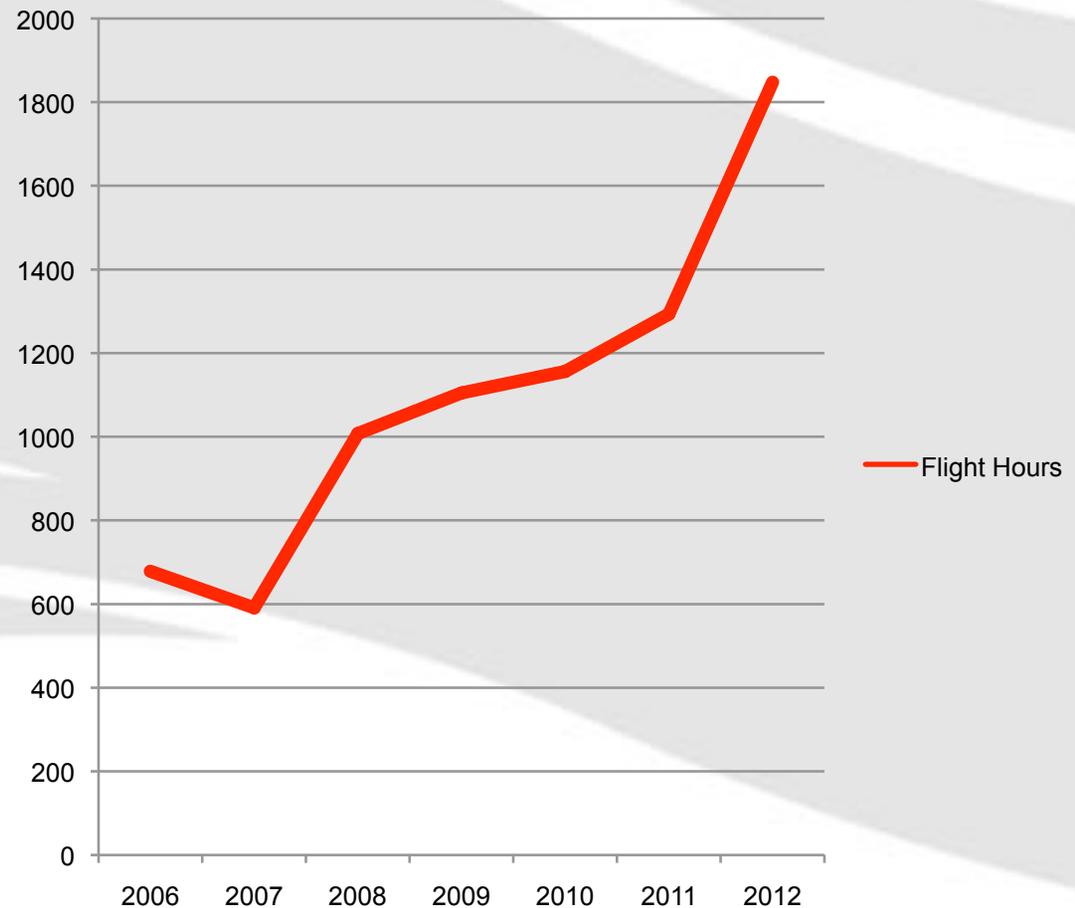


# Airborne Science Program DS Missions



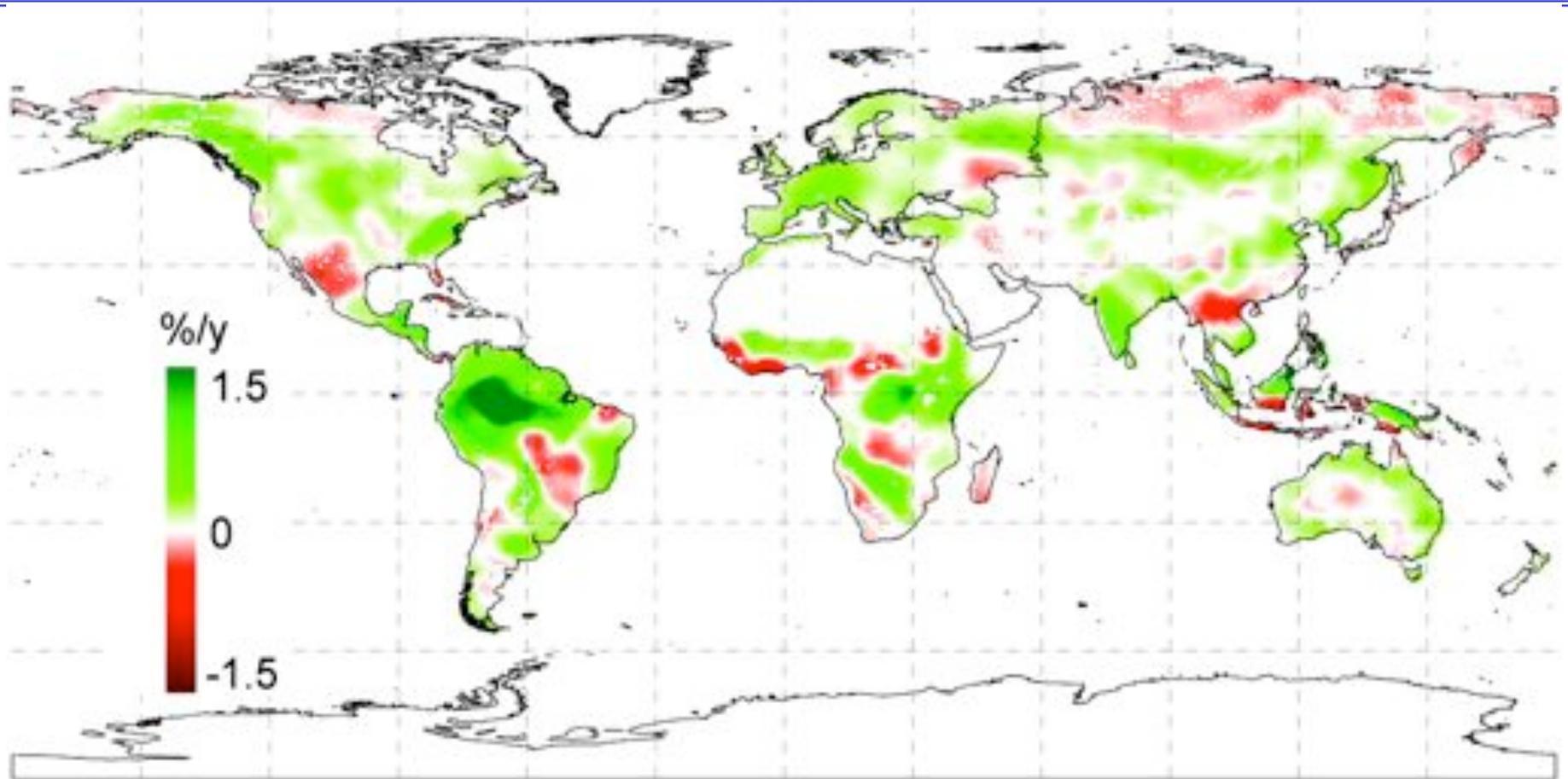
INTEX-B	2006
CC-VEX	2006
Arctic Sea Ice	2006
INTEX-B	2006
MILAGRO	2006
WRAP	2006-2009
Arctic Ice 2007	2007
CLASIC	2007
TC-4	2007
ARCTAS	2008
Calipso Caribbean	2008
CASIE	2009
ASCENDS test flights	2009
Racoro	2009
GloPac	2010
ABACATE	2010
GLEAM	2010
ASCENDS test flights	2010
AID for ASCENDS	2010
SIMPL	2010
MACPEX	2011
CAR	2011
4Star	2012
DC-3	2012
HEX	2012
SEAC4RS	2012
AVIRIS CONUS	2006-2012
UAVSAR	2006-2012
CLPX II	2007-2008
SMAPVEX	2008, 2010-11
OIB	2009-2015
Earth Venture 1	2011-2014

## ASP Flight Hours supporting DS Missions





## Climate change increased NPP from 1982 to 1999

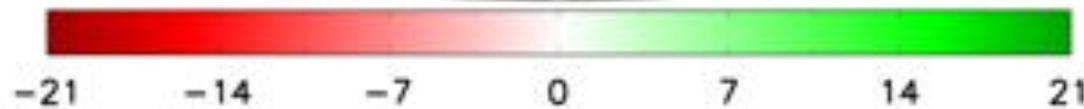
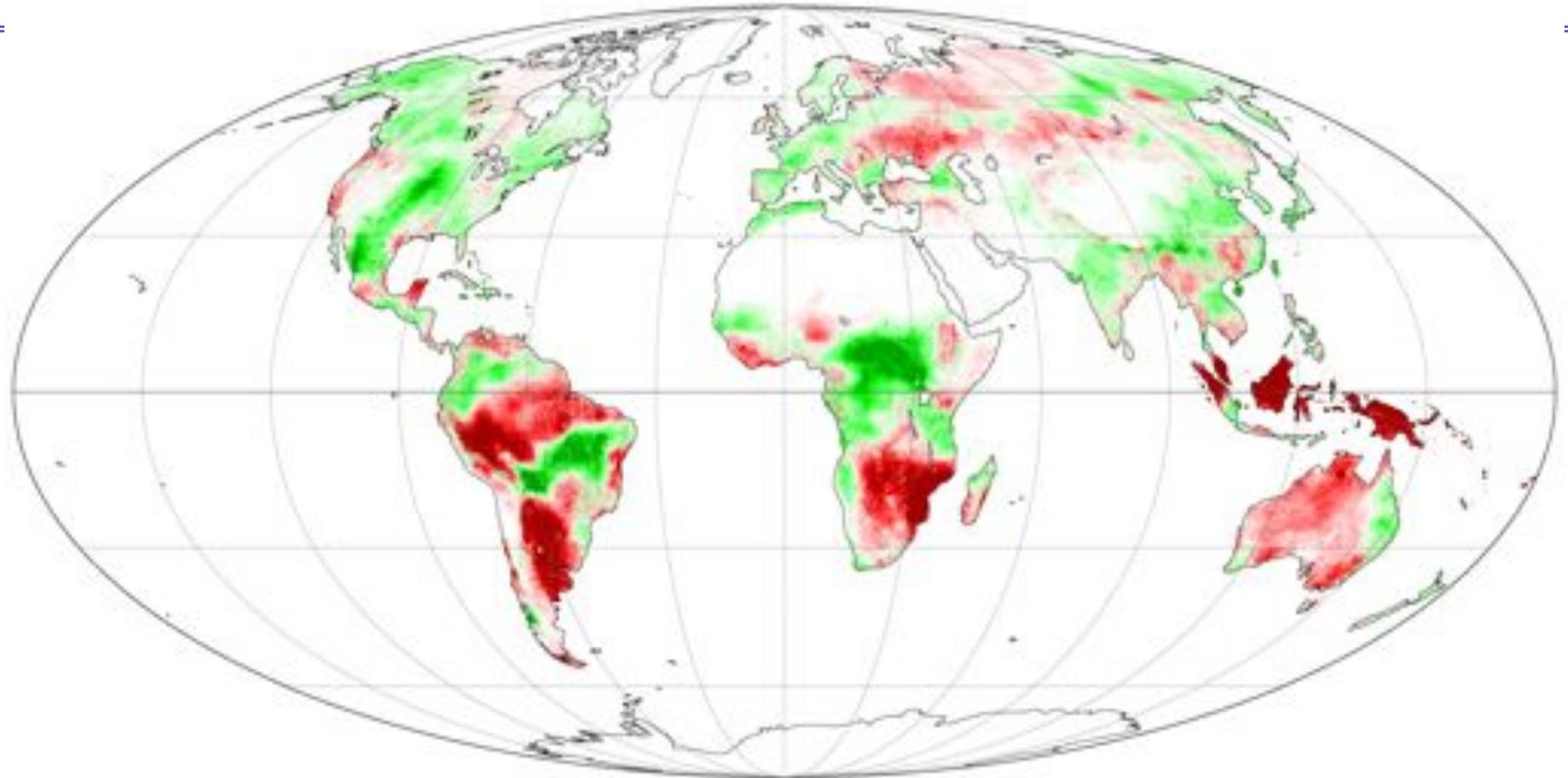


**AVHRR Data**

Nemani et al., 2003, *Science*



# Drought Decreased NPP from 2000 - 2009



NPP Trend (2000–2009) ( $\text{gC}/\text{m}^2/\text{yr}$ )  $\sim 0.1\%/\text{year}$  decline

**MODIS Data**

Zhao & Running 2010, *Science*

# KEY INTERAGENCY INTERACTIONS



- **USGCRP (Global Change Research Program)**
  - Freilich is USGCRP Vice-Chair – Integrated Observations Lead
  - Jack Kaye is ex-Acting USGCRP Chair, Integrated Strategic Planning Team member, NASA Principal
  - NASA is a major contributor to the National Climate Assessment activity, *the* major contributor to USGCRP
- **JPSS (Joint Polar Satellite System – ex-NPOESS)**
  - JASD Lead, coordinates with ESD
  - ESD NPP mission will be used operationally after launch for JPSS
  - Significant issues with NGST, NOAA
- **USGS/DOI**
  - Landsat follow-on under discussion (reimbursable – will be JASD execution)
- **Applied Science and R&A program investigations in collaboration with many Federal agencies (and non-Fed organizations)**
  - Field campaigns, joint solicitations, joint centers (e.g., JCSDA) support, collaborative multi-agency projects

# ESD Near-term Upcoming Launches



• Aquarius	6/2011	Delta-II	
• NPP	10/2011	Delta-II	
• LDCM	12/2012		Atlas-V (NLS-1 contract)
• <b>OCO-2</b>	<b>2/2013 !!</b>		<b>Taurus-XL !! (contract)</b>
• GPM Core	7/2013		H-IIA (JAXA)
• <b>[Jason-3 / NOAA</b>	<b>2014 ??]</b>		<b>?? (Taurus-XL was possible, LSTO in process)</b>
• <b>SMAP</b>	<b>3/2015</b>		<b>?? (LSTO in process)</b>
• SAGE-III	2015		SOMD – ATV, HTV to ISS
• <b>ICESAT-2</b>	<b>2016</b>		<b>Atlas-V rideshare ??</b>
• GRACE-FO	2016		Int'l Partnership
• <b>[JPSS-1 / NOAA</b>	<b>2016/17 ??]</b>		<b>??</b>

OCO-3 (avail. 2015) is instrument for MoO, possibly ISS



# BACKUP

# NON-FLIGHT RESEARCH AND APPLICATIONS ACTIVITIES



The FY2011 budget augmentation enables several key research, applications, technology, and education activities to be initiated or greatly expanded. These non-flight activities both enable the new space missions and provide the scientific and societal benefits from the spaceborne measurements.

- Modeling, assessment, and computing activities to expand NASA's contribution to the 2013 National Assessment by the USGCRP and the next mitigation and adaptation (Working Group II) assessment of the IPCC;
- Acceleration of operational use of NASA research data to improve climate prediction and weather forecasting, including expansion of SERVIR to additional nodes in strategic locations in the developing world in collaboration with USAID, and expansion of the sources and types of information products available to and from SERVIR nodes;
- Synthesis of NASA Earth Science observations via expanded opportunities for competitively-selected Interdisciplinary Science investigations and key mission science team work;
- Calibration of multi-satellite global data sets to enable increasing leverage of international data contributions, furthering the goals of USGEO and GEOSS;
- Development of NASA's contributions to a national Carbon Monitoring System in collaboration with other federal agencies;
- Expanded Earth Science Technology Program to provide the technology advances needed to enable accelerated implementation of Decadal Survey Tier 2 & 3 missions;
- Commensurate investment in Earth Science education programs such as GLOBE to assure that new Earth science understanding is infused in the nation's education curricula and that an educated workforce and populace is equipped to use the results of NASA's Earth Science program.

# Integrated Program for Water Availability/Quality



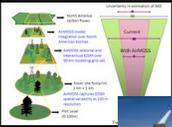
- Precipitation
  - TRMM (extended mission w/JAXA); Field Campaigns (e.g. GRIP, EV-1 Hurr. & Severe Storm Sentinel [HS3]); GPM (7/2013 w/ JAXA)
- Soil Moisture and Freeze/Thaw State
  - SMAP (5/2015 w/CSA)
- Inland Waters
  - SWOT (late 2019 w/CNES, CSA)
- Subsurface Ground Water (Aquifer Volume Changes)
  - GRACE (extended mission w/ Germany); GRACE-FO (2016 w/ Germany)
- Glacier and Ice Sheet Volume Changes and Dynamics
  - ICEBRIDGE (ongoing); ICESAT-2 (2016); DESDynI (2017)
- Coastal Water Quality
  - PACE (2019/2020 w/ CNES [likely])
- Northern Latitude Land, Lakes, Permafrost
  - EV-1 CARVE, SMAP, SWOT, GRACE-FO, ICESAT-2, DESDynI
- Accelerated Operational Use of Research Measurements, ...

# Integrated Carbon Cycle Research, Monitoring, Products



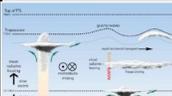
- Based on existing Carbon Cycle and Ecosystem R&A Focus Area
- Global Measurements of Atmospheric CO<sub>2</sub>
  - OCO-2 (2/2013)
  - OCO-3 (2015; instrument for flight of opportunity)
  - ASCENDS (2019-2020)
- Global Measurements of Terrestrial Aboveground Biomass
  - ICESAT-2 (2016; supporting lidar measurements)
  - ~~DESDynI radar/lidar (2017)~~
- Global Measurements of Oceanic Productivity
  - VIIRS(?) (2011/NPP, 2015??/JPSS)
  - PACE (2019; ocean-optimized radiometry, polarimeter)
- Development, Evaluation, and Evolution of Observationally-Based Carbon Products
  - Sustained Pilot Projects

# EARTH VENTURE-1



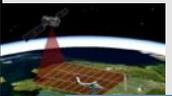
## **Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) - Univ Mich/JPL**

North American ecosystems are critical components of the global exchange of the greenhouse gas carbon dioxide and other gases within the atmosphere. To better understand the size of this exchange on a continental scale, this investigation addresses the uncertainties in existing estimates by measuring soil moisture in the root zone of representative regions of major North American ecosystems. Investigators will use NASA's Gulfstream-III aircraft to fly synthetic aperture radar that can penetrate vegetation and soil to depths of several feet.



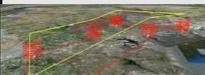
## **Airborne Tropical Tropopause Experiment (ATTREX) - ARC**

Water vapor in the stratosphere has a large impact on Earth's climate, the ozone layer and how much solar energy the Earth retains. To improve our understanding of the processes that control the flow of atmospheric gases into this region, investigators will launch four airborne campaigns with NASA's Global Hawk remotely piloted aerial systems. The flights will study chemical and physical processes at different times of year from bases in California, Guam, Hawaii and Australia.



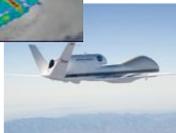
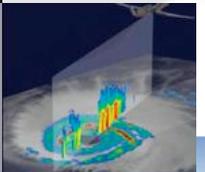
## **Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) - JPL**

This investigation will collect an integrated set of data that will provide unprecedented experimental insights into Arctic carbon cycling, especially the release of the important greenhouse gases such as carbon dioxide and methane. Instruments will be flown on a Twin Otter aircraft to produce the first simultaneous measurements of surface characteristics that control carbon emissions and key atmospheric gases.



## **Deriving Information on Surface Conditions from COLUMN and VERTICALLY Resolved Observations Relevant to Air Quality (DISCOVER-AQ) - LaRC**

The overarching objective of the DISCOVER-AQ investigation is to improve the interpretation of satellite observations to diagnose near-surface conditions relating to air quality. NASA's B-200 and P-3B research aircraft will fly together to sample a column of the atmosphere over instrumented ground stations.



## **Hurricane and Severe Storm Sentinel (HS3) – GSFC/ARC**

The prediction of the intensity of hurricanes is not as reliable as predictions of the location of hurricane landfall, in large part because of our poor understanding of the processes involved in intensity change. This investigation focuses on studying hurricanes in the Atlantic Ocean basin using two NASA Global Hawks flying high above the storms for up to 30 hours. The Hawks will deploy from NASA's Wallops Flight Facility in Virginia during the 2012-14 Atlantic hurricane seasons.

# Earth Science Technology: Program Elements

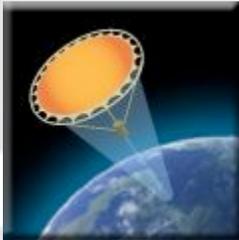


The *Earth Science Technology Office (ESTO)* is a **targeted, science-driven, competed, actively managed, and dynamically communicated technology program** and serves as a model for technology development.

Competitive, peer-reviewed proposals enable selection of best-of-class technology investments that **retire risk** before major dollars are invested: a cost-effective approach to technology development and validation.

ESTO investment elements include:

## Observation Technologies:



### **Instrument Incubator Program (IIP)**

provides robust new instruments and measurement techniques

### **Advanced Component Technologies (ACT)**

provides development of critical component and subsystem technologies for instruments and platforms

## Information Technologies:



### **Advanced Information Systems Technology (AIST)**

provides innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products and knowledge

# Earth Science Technology: New Investments Enabling the Decadal Survey



Upon publication of the Earth Science Decadal Survey in 2007, ESTO investments **already supported all 18 of the recommended mission concepts**. Since then, ESTO has awarded **74 additional technology projects** representing an investment of **over \$172M directly related to the Earth Science priorities outlined by the Decadal Survey**.



# INTERNATIONAL COLLABORATIONS (1 of 2)



- **European Space Agency**
  - NASA-ESA Earth Science collaboration framework signed September 2010 (Weiler-Liebig)
    - Field Campaigns/Cal-Val; Ground systems, data products, mission “interoperability”; Flight missions
- **ISRO (India)**
  - Oceansat-2 scatterometer, ocean color instrument data exchange, validation
  - QuikSCAT re-orientation to allow use as transfer standard
- **CNES (France)**
  - SWOT (72%/28%\$\$ NASA/CNES work package agreed upon, Weiler/d’Escatha)
  - Polder-FO (polarimeter) for PACE under discussion
- **CSA (Canada)**
  - SMAP (Flight components, ground station under discussion; validation)
  - SWOT (Flight components; science participation)

# INTERNATIONAL COLLABORATIONS (2 of 2)



- **CONAE (Argentina)**
  - COSMIC real-time data provision (w/ NOAA)
  - SAC-D/Aquarius full mission collaboration
- **JAXA (Japan)**
  - TRMM, ASTER, AMSR-E extended missions
  - ALOS-TDRSS operational data transmission until mission end (April 11)
  - GOSAT/ACOS/OCO-2 (validation, OCO-2 algorithm refinement)
  - GPM
- **DLR/GFZ (Germany)**
  - GRACE extended mission
  - GRACE-FO productive discussions, same workshare as GRACE
  - DESDynI Radar unlikely but under discussion
- **INPE (Brazil)**
  - ~~GPM Low-Inclination Orbiter discussions increasing~~